3aED8. Effectiveness of technical listening training in Department of Acoustic Design of Kyushu University
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What is the professional listening? Sound/Acoustic Professionals listening categorized into three phases. The ability to discriminate between different sounds. The ability to correlate the auditory difference with the physical properties of sounds. And the ability to imagine the proper sounds when given the acoustic properties of the sounds. The ability can be trained through listening training. Through trainings, trainees can share their auditory experience. The shared experience reinforces trainees to express their auditory impression with coherent words. And the use of coherent words supports smooth communication in their group. This word coherency is also the professional listening ability. In this paper, as a listening training, Technical Listening Training in Kyushu University was described. And we evaluated learning effects of training with average correct answer ratio among trainees. Trends of increasing correct answer ratio with training times were observed. We could show the effects of Technical Listening Training.

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INTRODUCTION

Audio and acoustic professional, for example, recording engineers, sound reinforcement engineers, concert hall acoustic designers, designer of musical instruments and audio system engineers are required special auditory sensitivity. They listen sounds professionally. In this paper, as a listening training, the overview and effectiveness of Technical Listening Training in Kyushu University[1] is described. To evaluate the effectiveness of training, the average correct answer ratios of trainees were examined through the training.

PROFESSIONAL LISTENING

In this paper, "professional listening" is defined with following abilities [1].

- The ability to discriminate between different sounds.
- The ability to correlate the auditory difference with the physical properties of sounds.
- The ability to imagine the proper sounds when given the acoustic properties of the sounds.

The first ability is very essential. Professional should be able to identify various types of perceived differences, such as differences in pitch, loudness and timbre. These three elements are the most basic auditory aspects of sounds.

The second ability is required to basic professional work. The sound professional should expect to come across numerous technical terms expressing acoustic features, e.g. sound pressure level, frequency, and spectrum. When a sound professional needs to explain an auditory difference, this difference should be expressed using the appropriate technical term.

Furthermore, for sound professional required the third ability, imagination of sounds. just as expert musicians can imagine music by looking at a score. Design plans and specifications are described by the acoustical technical terms: e.g. transmission loss or reverberation time. Sound professionals should be able to imagine sounds upon inspection of specifications. When controlling audio equipment, the sound professional should be able to imagine the controlled sounds. For example, when recording engineers use sound effectors, such as equalizers and reverb processors, they can anticipate the processed sounds before controlling the effector.

These abilities described above could be trained. Training examples is described in section 3. The important thing we should keep reminded is through training, trainees can share their experience. The shared experience reinforces trainees to express their auditory impression with coherent words (expression). And the use of coherent words supports smooth communication in their group. This means listening training to be professionals strategically works well when the trainings are conducted in a group such as in a company or classes in a school.

LISTENING TRAINING EXAMPLE: TECHNICAL LISTENING TRAINING IN KYUSHU UNIVERSITY

As a listening training example, here author introduce a program of Technical Listening Training in department of acoustic design, school of design, Kyushu University[1]. The students in this department wish to be sound professional. Technical listening Training is very popular educational program among the students. Technical Listening Training is required for freshmen and sophomores, and the respective classes are called Technical Listening Training I and II. This chapter introduces the goals and practical pro-grams of Technical Listening Training.

Technical listening Training I

First-semester freshmen are enrolled in Technical Listening Training I. This class focuses on basic acoustic properties: frequency, sound pressure level and spectrum. Through the training, students develop a feel for hertz and decibel levels.

The class begins with discrimination tasks for pitch, loudness and timbre in order to increase sensitivity to auditory differences.

At the pitch discrimination training, students listen to pure tone pairs. The two tones have the same loudness and duration, but slightly different frequencies.
The frequency of the standard tone is constant (440 Hz) and that of the comparison tone is a few Hz higher or lower than the standard. The task of students is to indicate whether the comparison tone is higher or lower. At the easiest level, the frequency difference is 5 Hz (rather easy to differentiate), and at the most difficult level, the frequency difference reaches 1 Hz. When the frequency difference reaches 1 Hz, differentiation becomes more difficult because the difference approaches the difference limen.

The tasks of loudness and timbre discrimination are similar to the pitch discrimination task. For loudness discrimination, the answer is louder or softer. For timbre discrimination, the answer is same or different. Training for these tasks enhances sensitivity to auditory differences. Through these discrimination training tasks, students come to comprehend the various types of auditory differences and learn how to listen to a sound.

After discrimination training, the students undergo identification training. At the rehearsal sessions for this training, students learn the auditory features of physical properties of sound. Afterward, the students attempt to perform identification tasks.

The tasks vary in type: difference in sound pressure level, frequency of pure tones, center frequency of band noise, number of harmonics, amplitudes slope of harmonic components, and frequency of enhanced bandwidth of colored music.

First, as an example of this type of training, we introduce the identification training tasks for the difference of sound pressure level. In this training task, a short music excerpt is presented twice.

The first sound is the standard, and the second is attenuated from the standard. At the rehearsal session, students listen to a series of sound pairs and correlate loudness differences to differences in the sound pressure level. At the intermediate level, the difference in sound pressure level is 5 dB stepwise: from 0 to 20 dB or from 0 to 30 dB. At the advanced level, the difference in sound pressure level is 2 dB stepwise: from 0 to 10 dB. As the level difference is smaller, the task is more difficult.

The "decibel (dB)" is the unit of sound volume which is used for amplifier volume, control of mixing consoles, adjustment of equalizers, measurement standard of noise exposure, and attenuation level of sound-proof barriers. Sound professionals should understand the physical definition of the decibel. However, as sound professionals, this is not sufficient. Sound professionals should be able to correlate the loudness of sounds to the sound pressure level. Sound professionals should be able to frame the loudness difference in terms of decibels when presented with a change in volume. Training in sound-pressure-level-difference identification is provided in order to comprehend the decibel scales by ear. This training gives students the ability to "decibel" sounds.

Another important concept for sound professionals is "frequency." Frequency is a basic acoustic property which affects pitch and timbre. The feel for frequency is also crucial for sound professionals. Generally, acousticians use the term "frequency" in two senses. One is frequency of periodic wave as a signal (typically the frequency of a pure tone). The other is frequency response of acoustic equipment, an example of which is the frequency characteristics of loudspeakers. The Technical Listening Training program includes training tasks corresponding to both aspects.

One task involving the frequency response of audio equipment is the frequency of enhanced bandwidth of colored music. In this task, students listen to a pair of a short music excerpts: one is the standard and the other is the characterization of its acoustic spectrum. In this training task, a one-octave frequency region of the characterized sound is boosted by 10 dB. The standard and comparison sounds are from the same music source but have different acoustic spectra. The task of students is to identify the center frequency of boosted octave-bandwidth. The center frequency of enhanced bandwidth is 125, 250, 500, 1,000, 2,000, 4,000 and 8,000 Hz. Through this training, students learn the auditory characteristics of each frequency region of musical sounds and gain an understanding of the spectrum and frequency characteristics of audio equipment. In order to increase the effectiveness of the training, different genres of music are used, because key auditory characteristics differ according to the type of music or combination of musical instruments.

The other training task involving frequency is the identification of frequencies of pure tone and the center frequency of band noises. The frequency of these training tasks is also an octave-band step: 125, 250, 500, 1,000, 2,000, 4,000 and 8,000 Hz. This training helps students gain a sense of frequency.

In the case of pure tones, frequency correlates to pitch. Musicians having absolute pitch can identify the pitch of a sound by name without referring to a standard tone. Sound professionals should be able to identify the pitch by the "hertz" level; however, unlike absolute pitch musicians, sound professionals need not acquire extremely high resolution power. Of course, frequency sense is linked to timbre sense. The identification task involving the center frequency of band noise helps students to recognize the difference in timbre between discrete and continuous spectrum.
Identification tasks involving harmonic number and amplitude slope of harmonic components help to provide students with a sense of spectrum and harmonics. In these training tasks, students correlate acoustic spectrum to perceived timbre.

**Technical listening Training II**

First-semester sophomores are enrolled in Technical Listening Training II as an advanced course. This class consists of more practical training tasks, because students already have a knowledge of basic acoustics.

This course further explores the identification of enhanced frequency of colored music. The advanced task is identical to the basic task, but the boosted level is 6 dB.

In addition, students receive training in identification of low-cut and high-cut frequencies. In the low-cut frequency training, the low-frequency region of reproduced sounds from music excerpts is eliminated. Students compare the original and the low-cut sound and then judge the low-cut frequency. At the high-cut frequency training, the task of the student is to judge the high-cut frequency. Technical Listening Training II explores a wider variety of tasks throughout the acoustic spectrum.

As an advanced identification training exercise involving the sound pressure level difference, students practice the identification task of sound pressure level difference of one part of a music ensemble. In this training task, students judge the level balance between parts of the ensemble. This training simulates control of the mixing console used by recording engineers.

An additional identification task is identification of spectrum envelope slope using a music excerpt. There is a task to identify the time difference between two parts of an ensemble. Another goal of Technical Listening Training is an understanding of "reverberation time," which is the most fundamental concept in room acoustics. One task is identification of the reverberation time of a synthesized sound, and the other task is identification of the reverberation time of music.

**EFFECTIVENESS OF TRAINING**

FIGURE 1 shows typical learning curves of Technical Listening Training in Kyushu University. Averages of percentage of correct answers with standard deviations and minimum scores are plotted along the time line. These are learning curves of training of identification of sound pressure level of 5dB stepwise. The numbers of trainees were range from 30 to 36. Some trainees data who didn't respond to all of training pairs were removed. All of trainee used in this analysis ware freshmen of Department of Acoustic Design of Kyushu University. Learning curves show with training, average of percentage of correct answer was increased and standard deviation was decreased. Minimum score of percentage of correct answer was also increased. These results show the effectiveness of Technical Listening Training.
FIGURE 1. Learning curves of Technical Listening Training in Kyushu University. Averages of percentage of correct answers with standard deviations and minimum scores are plotted along the time line. These are learning curves of training of identification of sound pressure level of 5dB stepwise.

CONCLUSION

In this paper, Technical Listening Training was introduced. And to evaluate the effectiveness of training, the average correct answer ratios of trainees were examined through the training. The improvement of correct answer ratios was observed. We could show the effectiveness of Technical Listening Training.

REFERENCES